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MINOR STUDIES FROM THE PSYCHOLOGICAL  
LABORATORY OF VASSAR COLLEGE.

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COMMUNICATED BY M. F. WASHBURN.

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III. A STUDY IN THE COMPARISON OF TIME INTERVALS.

By EDITH A. ALVORD AND HELEN E. SEARLE.

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The object of the experiments to be described was to investigate the processes which occur in the mind of a person who is asked to estimate the length of one interval of time in terms of another. No attempt was made to test, except roughly, the accuracy of such estimations, and the conditions were purposely left as nearly like those of our everyday time judgments as possible. The intervals used as standard varied from three to twelve seconds, and were thus much longer than those employed in 'time sense' experiments. The weight of the study rests upon the introspective testimony of the observers as to their methods of judgment.

The observer sat in as quiet a room as could be obtained. The experimenter marked off the intervals by striking a telegraph key at the beginning, at the end of the first or standard interval, and at the end of the second interval. The latter was made from ten to twelve times as long as the first, and followed directly after it, one and the same click of the key marking the end of the first interval and the beginning of the second. The observer was asked to state at the end of the experiment how many times the first interval was contained in the second. The only direction that was given her was that the times were not to be measured by filling them with counting; she was at liberty to use any other method that seemed natural. Furthermore, the length of the standard interval was varied so that a shorter and a longer one were given alternately.

The five observers, all fairly practised in introspection, differed decidedly in the methods they adopted, and may be considered separately.

Observer S., in by far the greater proportion of the experiments upon her, judged the length of the standard interval in terms of muscular strain and relaxation, and that of the comparison interval by noting how many times the strain reached the same degree of intensity as at the end of the standard.

The strain and relaxation were expressed by S. in different ways, sometimes by the effort of climbing imaginary stairs and dropping back at the end of the unit interval; sometimes by thinking of herself as running a race and stopping now and then; sometimes simply in terms of tension in the head. The first forty experiments alternated a standard of five seconds with one of ten seconds; the second forty, a standard of three seconds with one of six seconds. In all the statements of results given below, the amount of the average error is mentioned, together with its sign. Thus when for the five second standard the error is said to be +.5, this means that while the longer of the two intervals was really twelve times the standard, D.'s average estimate of it in twenty experiments was 12.5. Thus the standard interval, as reproduced by D. during the longer interval, was slightly underestimated, since more of the reproduced standards were put into the latter than were really contained in it. In like manner an error with negative sign means an overestimation of the standards.

The average errors of S. were, for a standard of 5 sec., +.5

For a standard of 10 seconds,	+2.0
" " " 3 "	-.8
" " " 6 "	+1.2

It will thus be seen that she overestimated the shortest interval, 3 seconds, slightly underestimated an interval of 5 seconds, and underestimated to an increasing degree intervals of 6 and 10 seconds. In the next set of forty experiments, made with standards of four and eight seconds alternately, S. made much less use of tension and relaxation and more use of a kind of auditory rhythm than that 'ran through her head.' Sometimes this rhythm became a tune, but oftener was without marked pitch differences. Her errors were:

For a standard of from 4 seconds,	-.1
" " " 8 "	+.8

The great accuracy of S.'s estimation of the four second interval is noteworthy. But more especially to be observed is the fact that the underestimation of the eight second standard is considerably less than that of the six second standard. In other words, while in general one might say, judging from these rough results, that S. had a tendency to overestimate intervals below five seconds and underestimate intervals above that limit, she underestimates less when she uses an auditory rhythm to judge by than when she uses strain and relaxation.

Observer Ald. did all her measuring in motor terms, not involving tension and relaxation, but merely imagined movement, probably a sort of rhythm with decided motor elements. She imagined her eyes moving along a line, her hand writing, her head bobbing up and down, her feet walking. The ex-

periments followed the same plan as with S. The following are the average errors:

Standard:	5 seconds.	Error:	-1.8
"	10 "	"	+1.6
"	3 "	"	-2.8
"	6 "	"	-5
"	4 "	"	-3.7
"	8 "	"	-1.05

Every standard except that of ten seconds was overestimated.

For observer W., the intervals measured themselves by an imagined auditory rhythm, and within the long interval, at the end of each period of time which was judged equal to this standard, the rhythm series came to an end with an auditory image of the count, 'three,' 'five,' etc. The standard itself was not filled with any rhythm; the latter set in usually shortly after the beginning of the large interval. The rhythm was during the first part of the long interval entirely independent of breathing, which was often quite irregular, but towards the end of the time the breathing tended to fit itself into the rhythm already established. A number of times it appeared to W. that the beats of the rhythm were synchronous with heart beats, and this was approximately verified by feeling the pulse at the close of the experiment; in other cases the rhythm seemed to be faster or slower in a way which the heart beat could scarcely account for. The following were the results for W.:

Standard:	4 seconds.	Average error,	-3.7
"	8 "	"	-1.05
"	6 "	"	-1
"	10 "	"	-4
"	5 "	"	-1
"	13 "	"	+2.8

It will be seen that W. resembles A. in overestimating every interval except the very longest one; and that even the ten second interval, which A. did shorten in reproduction, was lengthened by W. These results surprised W. herself, for she felt always in the case of the longer standards that her reproductions of them were too short. W. made almost no use of strain and relaxation as a method of measurement.

In observer F. still another method of reproduction showed itself. At the end of each of the first three to seven periods, within the longer interval, which was judged equal to the standard, a more or less distinct auditory image of the click of the key presented itself, as it were automatically, and the observer's attitude was simply that of waiting for this imaginary sound. The image accurately reproduced any slight peculiarity in the click such as was occasionally produced by the experi-

menter's not striking the key quite squarely. Sometimes as many as seven imaginary clicks were heard during the long intervals, but they tended to become less distinct as they were further removed from the original sound. When they did not occur, strain and relaxation sensations seemed to be used for measurement, and these were also experienced with the sound image. Once F. said there seemed to be "a contraction until the sound image came and then an explosion," and another time she said that "everything pulled towards the sound." Her results were as follows:

Standard:	5 seconds.	Average error,	—.6
"	10 "	" "	+2.4
"	6 "	" "	—.9
"	8 "	" "	+.3

We see again here the tendency to overestimate the shorter intervals and underestimate the longer ones, which was displayed by observer S.

The images of the sound of the key were reported also by the fifth observer, A., fluctuating as to distinctness and sometimes vanishing, but present in the majority of cases. Intervals without the auditory image were oftenest judged, Alv. said, 'mechanically,'—the meaning of this is uncertain. A sense of hurry was often experienced in experiments with the long standard. A.'s results were:

Standard:	5 seconds.	Average error,	—.2
"	10 "	" "	+2.4
"	3 "	" "	—.7
"	7 "	" "	+5.5

Like S. and F., this observer overestimates the short standards and underestimates the long ones. The very large underestimation of the 7 second standard is anomalous.

In spite of the individual differences thus brought out, there is a hint of a general principle to be found here. The two observers, S. and F., who reported the influence of strain and relaxation most frequently, show a tendency to make the longer standards too short in their reproduction of them. On the other hand the two observers Ald. and W., who usually filled the intervals either with imagined movements or with an auditory rhythm, noticing little or no strain, tend to make all the standards too long in their reproduction. Now to measure an interval by the increasing intensity of strain sensations produced as one waits for the end is decidedly fatiguing, on the testimony of the observers themselves, and there is a natural tendency to shorten the longer intervals as a result of this fatigue. On the other hand, when the intervals are mentally filled with a more or less varied content, involving no strain, and very little fatigue, the observer might have easily run a

little over the point of objective equality to the standard in her reproduction, especially where, as was the case with W., experiencing the standard interval itself did involve some strain, as she tried each time to impress herself anew with its length, and did not involve the auditory rhythm, which developed only in the long interval. It is too difficult to know what A. means by the 'mechanical' reproduction of the standard to interpret her results with certainty, but the method of measurement by waiting for the recurrence of an auditory image would naturally involve tension and relaxation, and, as we have seen, was explicitly reported to do so by F.

It is clear that speculation regarding the cause of the tendency shown by S., F. and A., to overestimate shorter standards and underestimate larger ones, is of little value owing to the roughness of the method of experimentation. We had some evidence that one influence at work here may have been derived from our procedure of giving a shorter and longer standard in alternation. This influence was the reverse of contrast, the standards tending to be mentally assimilated towards an intermediate value. A. was given a series in which a 9 second standard was used continuously, and this was overestimated, the error being  $-1.5$ , although 7 and 10 seconds had been underestimated by the other method. The auditory image played less part in A.'s introspection in this series, most of the judgment being described as mechanical. W., who overestimated everything below 13 seconds, which she underestimated when it was given in alternation with 5 seconds, the error being  $+2.8$ , underestimated 14 seconds given without alternation decidedly less, the error being only  $+.6$ . Ald., who also lengthened all the intervals but the longest used, 10 seconds, overestimated 8 seconds by an error of  $-1.05$  when it was used in alternation with 4 seconds, but by an error of  $-2.65$  when used alone; that is, there was a certain tendency in the direction of underestimation of this interval when used in alternation with a much shorter one, although the tendency did not amount to actual underestimation. S., on the other hand, who was given the standard of 4 seconds, with which she made the best record where short and long standards were alternated, the error being only  $-.1$ , in a series by itself, made an error of only  $-.2$ , so that it looked as though she found this interval especially easy to reproduce under any circumstances. F. was not tested on this point.

Rough as the experiments in this study are, their results indicate a few conclusions of some interest.

(1) There is great individual difference in the methods used for the reproduction of the standard interval; the principal ones

are strain and relaxation, imagined movements, auditory rhythm and the spontaneous occurrence of auditory images of the limiting stimulus.

(2) Where strain and relaxation were prominently concerned there was a tendency to shorten the longer standards, possibly on account of fatigue.

(3) Where a short and a long standard were alternately used no contrast effect whatever was visible; rather there were some indications of a tendency to assimilate the two towards an intermediate value.

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#### IV. THE LOSS OF ASSOCIATIVE POWER IN WORDS AFTER LONG FIXATION.

By ELIZABETH SEVERANCE and MARGARET FLOY WASHBURN.

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The phenomenon referred to in the title of this paper is one that is familiar to most people, but has never, so far as we are aware, been made the subject of experimental study. If a printed word is looked at steadily for some little time, it will be found to take on a curiously strange and foreign aspect. This loss of familiarity in its appearance sometimes makes it look like a word in another language, sometimes proceeds further until the word is a mere collection of letters, and occasionally reaches the extreme where the letters themselves look like meaningless marks on the paper. In the present study we have attempted to observe this process in detail and under experimental control.

To secure uniformity, the words used were all of six letters, printed in long primer type, cut out of the same periodical and placed upon a background of white paper. Words without capital letters were employed. The observers, six women, all with a fair amount of introspective training, were required to look fixedly at a word for a period of three minutes, measured by a stop watch, and to describe all the changes undergone by the appearance of the word. The approximate time of these changes was noticed. A few typical instances of the resultant phenomena are here given:

(1) Word: *career*. Observer: W.  
Time: 6 sec. *reer* stands out prominently and gives the word an unfamiliar look.

22 sec. Sound suggestion =care—er.

32 sec. “ “ =career, for a single instant.

46 sec. The second e looks like c; the sound of the Latin word *carcer* suggested.

1 min. 20 sec. No sound suggestion: the word looks entirely foreign.